

What is claimed is:

- 5 1. A transducer for converting between electrical energy and mechanical energy, the transducer comprising an electroactive polymer having a plurality of active areas, the plurality of active areas comprising:
a first active area having at least two first active area electrodes and a first portion of the electroactive polymer arranged in a manner which causes the first portion to deflect in response to a change in electric field provided by the at least two first active area electrodes and/or arranged in a manner which causes a change in electric field in response to deflection of the first portion; and
10 a second active area having at least two second active area electrodes and a second portion of the electroactive polymer arranged in a manner which causes the second portion to deflect in response to a change in electric field provided by the at least two second active area electrodes and/or arranged in a manner which causes a change in electric field in response to deflection of the second portion.
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- 20 2. The transducer of claim 1 wherein the first and second active areas are arranged such that deflection of the first portion includes a direction of contraction that is at least partially linearly aligned with a direction of expansion for the second portion.
- 25 3. The transducer of claim 1 wherein the plurality of active areas are symmetrically arranged.
4. The transducer of claim 1 wherein the at least two first active area electrodes and the at least two second active area electrodes are arranged radially around a central point.
- 30 5. The transducer of claim 1 wherein electrical communication between the at least two first active area electrodes and the first portion is independent from electrical communication between the at least two second active area electrodes and the second portion.

6. The transducer of claim 1 wherein one of the at least two first active area electrodes is electrically coupled to one of the at least two second active area electrodes.
7. The transducer of claim 6 wherein the one of the at least two first active area electrodes electrically coupled to the one of the at least two second active area electrodes is a common electrode.
8. The transducer of claim 1 wherein the polymer is elastically pre-strained.
- 10 9. The transducer of claim 1 wherein the transducer is included in one of a motor and a generator.
10. A device for converting between electrical energy and mechanical energy, the device comprising:
- 15 an electroactive polymer having a plurality of active areas, the plurality of active areas comprising:
- 15 a first active area having at least two first active area electrodes and a first portion of the electroactive polymer arranged in a manner which causes the first portion to deflect in response to a change in electric field provided by the at least two first active area electrodes and/or arranged in a manner which causes a change in electric field in response to deflection of the first portion,
- 20 a second active area having at least two second active area electrodes and a second portion of the electroactive polymer arranged in a manner which causes the second portion to deflect in response to a change in electric field provided by the at least two second active area electrodes and/or arranged in a manner which causes a change in electric field in response to deflection of the second portion; and
- 25 a substantially rigid member coupled to a third portion of the electroactive polymer.
- 30 11. The device of claim 10 wherein the polymer is elastically pre-strained.
12. The device of claim 10 wherein the first portion, the second portion and the third portion are separate portions of the polymer and wherein the third portion of the polymer is located at least partially between the first portion and the second portion of the polymer.

13. The device of claim 12 wherein the first and second active areas are arranged such that deflection of the first portion includes a direction of contraction that is at least partially linearly aligned with a direction of expansion for the second portion.

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14. The device of claim 13 wherein the length of an attachment between the substantially rigid member and the polymer in a direction perpendicular to a desired motion of the first active area is greater than 50% of the planar dimension of the active area perpendicular to the desired motion of the first active area.

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15. A method for using an electroactive polymer comprising a first active area and a second active area, the first active area having at least two first active area electrodes and a first portion of the electroactive polymer, the second active area having at least two second active area electrodes and a second portion of the electroactive polymer, the method comprising:

providing a change in electric field to the at least two first active area electrodes; and providing a change in electric field to the at least two second active area electrodes.

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16. The method of claim 15 further comprising mechanically deflecting the first portion before providing the change in electric field to the at least two first active area electrodes.

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17. The method of claim 16 wherein the change in electric field provided to the at least two first active area electrodes is less than the electric field needed to further deflect the first portion.

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18. The method of claim 17 further comprising mechanically deflecting the first portion after the change in electric field has been provided, wherein the mechanical deflection after the change in electric field has been provided increases the electrical field between the at least two first active area electrodes.

19. The method of claim 15 wherein the change in electric field provided to the at least two first active area electrodes deflects the first portion.
20. The method of claim 15 wherein the change in electric field provided to the at least 5 two second active area electrodes deflects the second portion.
21. The method of claim 20 wherein the second portion is deflected such that elastic energy of the first portion assists a deflection of the second portion.
- 10 22. The method of claim 21 wherein deflection of the second portion begins when the first portion is at a peak expansion.
- 15 23. The method of claim 15 further comprising actuating a third active area by providing a change in electric field to at least two third active area electrodes to deflect a third portion of the electroactive polymer.
- 20 24. The method of claim 23 wherein the first active area, the second active area, and the third active area provide three degrees of freedom for deflecting a fourth portion of the electroactive polymer.
- 25 25. The method of claim 23 wherein the first active area, the second active area, and the third active area are actuated sequentially to move a fifth portion of the electroactive polymer along a path.
27. The method of claim 15 wherein the change in electric field provided to the at least 30 two first active area electrodes terminates before the change in electric field provided to the at least two second active area electrodes begins.

28. A transducer for converting between electrical energy and mechanical energy, the transducer comprising an electroactive polymer having a plurality of active areas, the plurality of active areas comprising:

5 a first active area having a first electrode and a common electrode, and a first portion of the electroactive polymer arranged in a manner which causes the first portion to deflect in response to a change in electric field provided by the first electrode and the common electrode and/or arranged in a manner which causes a change in electric field in response to deflection of the first portion; and

10 a second active area having a second electrode and the common electrode, and a second portion of the electroactive polymer arranged in a manner which causes the second portion to deflect in response to a change in electric field provided by the second electrode and the common electrode and/or arranged in a manner which causes a change in electric field in response to deflection of the second portion.

15 29. The transducer of claim 28 wherein timing between deflection of the first portion in response to a change in electric field provided by the first electrode and the common electrode and deflection of the second portion in response to a change in electric field provided by the second electrode and the common electrode is modulated by the propagation 20 of an electrical charge through the common electrode.

30. The transducer of claim 28 wherein the common electrode has a resistivity in the range of about 0.01 MΩ to 50 MΩ.

25 31. The transducer of claim 28 wherein the first electrode and the second electrode are in electrical communication.

30 32. A transducer for converting between electrical energy and mechanical energy, the transducer comprising an electroactive polymer having a plurality of active areas, the plurality of active areas comprising:

a first active area having at least two first active area electrodes and a first portion of the electroactive polymer arranged in a manner which causes the first portion to deflect in

response to a change in electric field provided by the at least two first active area electrodes and/or arranged in a manner which causes a change in electric field in response to deflection of the first portion; and

a second active area having at least two second active area electrodes and a second

- 5 portion of the electroactive polymer arranged in a manner which causes the second portion to deflect in response to a change in electric field provided by the at least two second active area electrodes and/or arranged in a manner which causes a change in electric field in response to deflection of the second portion, wherein the electroactive polymer is elastically pre-strained.

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33. A device for converting between electrical energy and mechanical energy, the device comprising:

an electroactive polymer having a plurality of active areas, the plurality of active areas comprising:

15 a first active area having at least two first active area electrodes and a first portion of the electroactive polymer arranged in a manner which causes the first portion to deflect in response to a change in electric field provided by the at least two first active area electrodes and/or arranged in a manner which causes a change in electric field in response to deflection of the first portion,

20 a second active area having at least two second active area electrodes and a second portion of the electroactive polymer arranged in a manner which causes the second portion to deflect in response to a change in electric field provided by the at least two second active area electrodes and/or arranged in a manner which causes a change in electric field in response to deflection of the second portion;

25 a substantially rigid member having a first segment and a second segment, the first segment coupled to a third portion of the electroactive polymer, the second segment capable of motion assisted by deflection of the first portion of the polymer and/or capable of motion that causes a change in electric field in the first portion of the polymer; and

a frame coupled to a fourth portion of the polymer.

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34. The device of claim 33 wherein the third portion of the polymer is located at least partially between the first portion and the second portion of the polymer.

35. The device of claim 33 wherein the first and second active areas are arranged such that deflection of the first portion includes a direction of contraction that is at least partially linearly aligned with a direction of expansion for the second portion.
- 5 36. The device of claim 33 wherein the substantially rigid member is used as a driving member in a motor.